INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
11–190/AKP/2011/13–6–976–980
http://www.fspublishers.org

Full Length Article

Reproductive Biology of Danube Bleak, *Alburnus chalcoides* (Güldenstädt, 1772) in Tödürge Lake (Sivas, Turkey)

BÜLENT ÜNVER[1] AND MAHIR YILDIRIM
Cumhuriyet University, Department of Biology, 58140 Sivas, Turkey
[1]Corresponding author's e-mail: blnt58@gmail.com

ABSTRACT

In this study, some biological properties such as the age and sex distributions, age at first spawning, fecundity, dating of the spawning, minimum fishing size and closed period for the fishery of *A. chalcoides* living in Tödürge Lake, which is one of the important wetlands of Turkey, were determined. In total, 456 specimens of bleak were caught between April 1994 and November 1994. The age of sexual maturity was found to be II for male individuals and II–III for female individuals. The smallest female and male with mature gonads had 147 mm fork length and 39.5 g body weight and 119 mm and 20.1 g, respectively. It was determined that the specimens of *A. chalcoides* started to spawn in May and continued until the end of July. The number of eggs in the ovary and egg diameter ranged from 2265 to 16540 and from 0.10 to 1.35 mm, respectively. Fishing must be prohibited during the spawning period to ensure economic evaluation and the sustainability of the population. The smallest prey size allowed for commercial fishing must be based on the length and weight averages (158 mm; fork length, 49 g; body weight) of the age group III. © 2011 Friends Science Publishers

Key Words: Danube bleak; Reproduction; Tödürge lake

INTRODUCTION

Although Tödürge Lake is one of the important wetlands, which comprise remarkable fish and bird species in Turkey (Yarar & Magnin, 1997). Several studies have reported different biological characteristics of fish species (Unver, 1998; Ünver & Tanyolaç, 1999).

All species of *Chalcalburnus* were considered to belong to the genus *Alburnus* (Bogutskaya & Naseka, 2004; Freyhof & Kottelat, 2007). Danube bleak; *Alburnus chalcoides* (Güldenstädt, 1772) is a pelagic species, living in fresh and brackish water. The species is widely distributed throughout Black Sea, Caspian Sea and Aral Sea basins (Geldiay & Balık, 1988). Dense populations of this species are commonly found in few streams (Sakarya, Kızılırmak, Yeşilırmak & Kura Streams) flowing to the Black Sea and the tectonic lakes in the Marmara Region (Northwestern Anatolia) (Geldiay & Balık, 1988; Bogutskaya, 1997). This species is also abundant in Tödürge Lake, which is located in the Kızılırmak Basin and the local people and cooperatives commercially exploit by traditional fisheries (Unver, 1998).

In order to establish sustainable fishery biological characteristics like sexual maturity age and size, fecundity and reproductive period of individuals are required (King, 2007). The routine method in such studies is to observe seasonal developmental changes in the gonads.

Slastenenko (1955) has stated that the size at maturity was 14-18 cm (FL) when the fish is two or three years old and spawning was started in May, fecundity determined as 24.000. Geldiay and Balık (1988) have reported that the reproduction period of *A. chalcoides* was contained between May and July, and a bleak laid almost 23.000 eggs on a bed covered with pebbles or larger stones. In Demirköprü Dam Lake, the first spawning age for males and females was determined as I and II, respectively. Spawning period of this species was between May and June, and fecundity 5.775-50.446 eggs (Balık & Sarı, 1994). Akyurt and Sarı (1991) and Balık *et al.* (1996) have examined some biological properties of bleak in Lake Manyas, Tozanlı Stream and Çevresu-Çalkara drainage canal, respectively. Herzig and Winkler (1986) have demonstrated the influence of temperature on the embryonic development of *A. chalcoides mento*. However, only limited information is available on biological characteristic such as sexual maturity age, fecundity and reproductive period of different populations of this species in Turkey. This study therefore, aimed to determine age and sex distributions as well as reproductive properties (age at first spawning, fecundity & the dating of the spawning) of *A. chalcoides* living in Tödürge Lake to gain further insight into the biological features of Danube bleak in Turkey.

MATERIALS AND METHODS

Between April 1994 and December 1994, fish samples (in total 456 specimens) were analyzed in the laboratory to assess the reproductive characteristics (age & size at

To cite this paper: Ünver, B. and M. Yıldırım, 2011. Reproductive biology of Danube bleak, A*lburnus chalcoides* (Güldenstädt, 1772) in Tödürge lake (Sivas, Turkey). *Int. J. Agric. Biol*., 13: 976–980

maturity, reproductive period & fecundity) of *Alburnus chalcoides* caught from Tödürge Lake.

Fish were caught by means of five gillnets, each with different length, height and mesh sizes (15x15, 18x18, 20x20, 24x24 & 32x32 mm) and with 15 day or monthly periods. Catching localities were determined by taking into considering of the spawning area and period of the species.

After being caught, the fish samples were transported to the laboratory in an icebox and their sizes recorded in terms of fork lengths (L_F; ±0.1 cm). Body and gonad weights of the samples were determined by using a balance (±0.1 g). Age determination from the scales was carried out according to the method of Lagler (1956) and grouped into 0, I, II, III, IV and V ages.

All specimens were classified by macroscopic examination of the gonads as male, female, or immature. The gonads were removed and weighed to the nearest 0.1 g and classified as immature, or as one several stages of sexual maturation, from resting to post spawning. Gonad classification applied only to gonadal morphology (Nikolsky, 1963; West, 1990). The smallest size class in which 50% of individuals were sexually mature (Mat_{50}) was determined to provide estimates of the sizes of sexual maturation of males and females in the bleak population.

The gonadosomatic index (I_G) was calculated (West, 1990). The spawning period of *A. chalcoides* population in Tödürge Lake was determined by means of the monthly changes in the gonadosomatic index (I_G), egg diameter and egg number in per one gram ovary.

The mean egg diameter for each female was determined by random sampling of 60 eggs measured under a binocular stereo microscope (Olympus BX51, Japan) using an ocular micrometer. Total fecundity was estimated by the gravimetric method: the mean number of yolky, late-stage vitellogenic oocytes in per one-gram ovarian tissue was estimated and multiplied by the total ovarian weight. The spawning ratio (%) of the population captured between April-August, were determined using spawned-unspawned samples from 168 fish specimens.

Evaluation of all data and statistical analysis were performed by using SPSS software for Windows (version 14.0, SPSS Inc., Chicago).

RESULTS

The specimens were analyzed by age, sex group, average values for fork length, and weight. The fork length and weight of captured 456 fish specimens ranged from 43 to 213 mm and from 0.50 to 116.00 g, respectively. The measured age range of the specimens was between 0 and 5 years, and it was found that 4th age group was dominant in the population. Females constituted 82.0% of bleak specimens captured from Tödürge Lake. Therefore, sex ratio was about 1.0:0.2, which was very much different from that of the expected (1.0:1.0). There was preponderance in the number of females in the 4th and 5th age groups.

A total of 140 specimens were analyzed to determine the states of gonad maturation. The obtained results indicated that the onset of maturity of bleak population living in Tödürge Lake occurred at the age of II for males and at the age of II and III for females (Table I). The smallest female and male with mature gonads was found to be 147 mm in fork length and 39.5 g in body weight and 119 mm and 20.1 g, respectively.

The spawning period of *A. chalcoides* population appeared to depend on the seasonal changes of gonado-somatic index (I_G), egg diameter, egg number in per one gram ovary and ratio of spawning. Gonado-somatic index (I_G) was calculated from gonad samples taken monthly. The variation of an average, minimum and maximum values for female and male of *A. chalcoides* (419 individuals) are given in Table II. I_G values varied from 0.51 to 21.38 for females, from 0.34 to 8.70 for males. The maximum values of I_G were determined in May for females and in April for males. However, in August the index revealed minimum values for both sexes.

It was shown that the average, minimum and maximum values for ovarium weight, egg diameters and egg numbers in per one gram ovarium of *A. chalcoides* varied monthly (Table III). Ovarium weight, egg diameter and egg numbers in per one gram ovarium were found to vary seasonally. The average egg diameter reached a maximum value in May (1.08 mm) and minimum value in August (0.31 mm) when the ovaries contained only those oocytes that would develop the following year. There was a gradual increase in egg diameter from September onwards until the new spawning season. The minimum value of egg number in per one gram ovarium was observed as 921 in May and its maximum value as 2874 in October.

The number of spawned-unspawned fish from 168 specimens captured between April-August, was determined. According to macroscopic observation of gonads, the egg-laying commenced in the second half of May. The ratio of spawned fish was 9.5% in May. It reached 50% in July and no ripe fish were found in August (Table IV).

According to the seasonal changes in the gonado-somatic index, egg diameter, egg number in per one gram ovarium and ratio of egg laying, it was revealed that the spawning in *A. chalcoides* population began in May and continued until end of July.

Average, minimum and maximum egg numbers of *A. chalcoides* as a function of age groups, variation coefficients and the proportional (%) incremental values [PIV (%)] of the average egg numbers (Table V). Egg numbers in the ovary varied from 2265 to 16540. Average egg numbers for II. and V. age groups were 3020 and 13424, respectively. The proportional incremental values decreased with increasing age of fish.

Table I: Maturity stages of *A. chalcoides* individuals according to age groups (%)

Maturity (%)		Age Groups				
		0	I	II	III	IV
♀	Immature	100.0	100.0	50.0	10.3	–
	Mature	–	–	50.0	89.7	100.0
♂	Immature	100.0	87.5	40.0	–	–
	Mature	–	12.5	60.0	100.0	100.0

Table II: The average gonado-somatic index values of *A. chalcoides* individuals

Months	Female			Male		
	N	I_G ±SE (min.-max.)	V	N	I_G ±SE (min.-max.)	V
April	20	11.96±0.46 (8.49–16.28)	17.4	2	8.43±0.26 (8.17–8.70)	4.4
May	70	14.05±0.44 (3.39–21.38)	26.4	10	5.31±0.81 (1.32–8.21)	48.2
June	20	9.27±0.89 (2.99–16.14)	42.8	2	2.18±1.58 (0.60–3.76)	102.7
July	17	2.99±0.91 (0.51–12.92)	125.1	1	1.11	–
August	44	1.43±0.07 (0.78–3.26)	34.3	3	0.43±0.07 (0.34–0.56)	27.9
September	20	2.51±0.16 (1.22–3.89)	29.1	2	0.75±0.09 (0.66–0.85)	17.3
October	147	4.10±0.08 (0.58–7.31)	22.9	41	1.43±0.05 (0.78–2.10)	20.9
November	15	5.18±0.29 (3.76–7.33)	21.4	5	1.32±0.13 (1.06–1.72)	22.7

N: individual number, I_G: gonado-somatic index, SE: standard error, V: variation coefficient, (min.-max. gonado-somatic index)

Table III: The average of egg diameter and egg number in per one gram ovarium of *A. chalcoides* individuals

Months	N	r±SE (min.-max.)	V	N	n±SE (min.-max.)	V
April	13	0.94±0.01 (0.74–1.11)	9.6	8	1116.9±55.8 (913–1453)	15,8
May	20	1.08±0.02 (0.67–1.35)	14.8	11	920.8±21.3 (778–1013)	7.3
June	12	0.73±0.02 (0.42–0.96)	19.2	9	1026.3±46.9 (815–1225)	12.1
July	14	0.56±0.03 (0.17–1.08)	46.4	9	1118.0±65.4 (885–1332)	15.5
August	34	0.31±0.01 (0.10–0.67)	38.7	18	1257.9±54.4 (1006–1423)	11.4
September	17	0.39±0.01 (0.13–0.61)	28.2	II	1886.6±125.0 (1259–2665)	23.9
October	84	0.45±0.01 (0.19–0.69)	26.7	26	2874.2±105.4 (1995–3159)	11.6
November	14	0.42±0.01 (0.12–0.66)	30.9	8	2808.5± 100.6 (1983–3059)	11.3

N: individual number, r: egg diameter (mm), n: egg number, SE: standard error, V: variation coefficient

Table IV: Ratio of spawning (%) for *A. chalcoides* samples

Months	N	Ratio of Non-Spawning (%)	Ratio of Spawning (%)
April	20	100.0	–
May	63	90.5	9.5
June	20	50.0	50.0
July	17	17.7	82.3
August	48	–	100.0

N: individual number

Table V: The average egg numbers of *A. chalcoides* individuals

Age groups	N	n_{ave}±SE (min.-max.)	V	PIV (%)
II	5	3020±168.7 (2265–3775)	17.7	–
III	17	7053±163.2 (6418–8127)	7.3	133.6
IV	33	13072±1177.4 (9665–16540)	22.1	85.3
V	5	13424±920.0 (10630–16440)	16.8	2.7

N: individual number, n_{ave}: average egg numbers, SE: standard error, V: variation coefficient, PIV (%): proportional incremental values, (min.-max. egg number)

DISCUSSION

Sex ratio in a population is considered to be important factor for its development and sustainability. Generally, this ratio is expected to be 1:1 for the young populations (Nikolsky, 1963). The examined specimens of *A. chalcoides* consisted of 82.0% females and 18.0% males. Animal populations scarcely have 1:1 female-male ratio. In most of the populations, either of the sexes predominates. While in the early years of life the number of males was higher than females, in the late years, the females become more abundant (Nikolsky, 1963). In the present study, there was

an increase in the number of females in the 4th and 5th age groups. On the other hand, the ability of hatching out was generally higher for males than females (Nikolsky, 1963). In a study performed at a dam Lake, female-male ratio has been shown to be 1:0.77 (Balık & Sarı, 1994). The unequal sex ratios may be related to the different growth rates and longevity of *A. chalcoides* populations, and may also depend on the difference of sex physiology, migration or niche, since the males usually approach the spawning ground first, and remain there longer and participate in the spawning with several females (Nikolsky, 1963).

The age distribution for the population gives an idea about both reproduction power and the future of the population (King, 2007). The relative strengths of the different age groups and the maximum life span are, within certain limits, a specific adaptive property of a given species. Fish populations with short life cycle and consisting of only a few age groups, are adapted to live under the conditions of a very high mortality and variable food supply (Nikolsky, 1963). Examined specimens having a broad range of age distribution (0-V) indicated that the Tödürge Lake afforded a suitable ecology for the growth and reproduction of the *A. chalcoides* population. The age composition of the *A. chalcoides* population in other localities have been reported to change between I, IV (Demirköprü Dam Lake, Tozanlı Stream & Çevresu-Çalkara drainage canal), and VIII (Aral Lake) (Berg, 1949; Akyurt & Sarı, 1991; Balık & Sarı, 1994).

The age at sexual maturity varied as a function of growth rate in the juvenile period. Male individuals had sexual maturity one or two years earlier than females due to the rapid growth of females for first ages (Nikolsky, 1963; King, 2007). Male specimens of the *A. chalcoides* population reached maturation at the age of II, whereas females reached at the ages of II and III (Table II). Slastenenko (1955) has found the maturity age to be II-III. On the other hand, in Demirköprü Dam Lake, the first spawning age for males and females has been determined to be I and II, respectively (Balık & Sarı, 1994). In the majority of widely distributed species, maturity usually sets in later at higher latitudes. The abundance of the food also exerts a direct influence upon the time of onset of maturity. When populations are reduced under natural conditions, leading to an improvement in the food supply, an acceleration of the maturation of the individuals has often been observed (Nikolsky, 1963). The age of sexual maturity may also be influenced by some abiotic factors such as water temperature, photoperiod or by other environmental factors in different localities (King, 2007).

The time of onset of maturity therefore, appear to be subject to considerable variation among different populations of the same species and also within a given population. The onset of maturity is often related to the attainment of a particular size by an individual specimen (Nikolsky, 1963). In the present study, it was observed that the smallest female and male with mature gonads was 147 mm in fork length and 39.5 g in body weight, and 119 mm and 20.1 g, respectively. The development of the gonads is connected in the majority of fishes with the formation of secondary sexual characteristics. The most frequent secondary sexual difference is that of size between the sexes. The female is usually larger than the male, which ensures the largest fecundity of the stock. This difference in size is often achieved through the earlier maturation of males and their shorter life span (Nikolsky, 1963). Slastenenko (1955) have stated that the size at maturity in 14-18 cm (FL) when the fish was two or three years old in Black Sea Basin. In Demirköprü Dam Lake, the length of first spawning has been determined to be 18.80-20.46 cm (Balık & Sarı, 1994).

The period during which the gonado-somatic index and egg diameter values were maximum, and the egg number in per one gram ovarium was minimum, was considered the beginning of the spawning period for the mature pre-spawning females (Nikolsky, 1963). In the present study, the average gonado-somatic index reached a maximum value in April and May for male and female, and the minimum value was obtained in August for both sexes (Table III). The egg number in per one gram ovarium was at minimum in May when the average egg diameter was at maximum (Table IV). Gonadal evaluations revealed that the spawning period for the *A. chalcoides* population in Tödürge Lake began in May and continued until the end of July, and the sexual resting also extended from September to March. In Demirköprü Dam Lake, the average gonado-somatic index has been reported to range from 1.35 to 8.15, and egg diameters from 0.24 to 1.48 mm. The highest values were attained in May and this was accepted as the beginning of the spawning period (Balık & Sarı, 1994).

Our results were confirmed by the macroscopic examinations of the 168 fish ovaries from April to August (Table V). When the ratios of egg laying were analyzed, it was appeared that the spawning commenced in the second half of May and continued until the end of July. Geldiay and Balık (1988) have reported that the reproduction period for the *A. chalcoides* individuals was between May and July. On the other hand, Herzig and Winkler (1986) and Balık and Sarı (1994) have determined this period as May-June. The same species will often spawn at different times of the year in different regions according to the ecological and geographic conditions (Nikolsky, 1963).

The spawning migration is a movement away from the overwintering or feeding grounds to the spawning grounds (Nikolsky, 1963). It has been previously reported that the adult individuals of bleak after April, began to migrate to Acısu Stream, which flows into the lake and they laid eggs on a bottom covered with sand or pebbles in relatively fast-flowing and shallow sites of the stream (Unver & Erk'akan, 2005). The bleak is a lacustrine and rheophilous species and migrate upstream for spawning (Slastenenko, 1955; Geldiay & Balık, 1988). We also observed that the run of the adult

bleak, with massive shoals, began in May from the lake to Acısu Stream.

The number of eggs contained in the ovary of a fish is termed as individual, absolute or total fecundity (Nikolsky, 1963). Due to their small size, the average fecundity values of the *A. chalcoides* individuals varied between age groups, and appeared to be lower than the population of Demirköprü Dam Lake (Balık & Sarı, 1994). At the age of II, the average fork length and fecundity has been determined to be 20.14 cm and 28790 eggs, respectively in Demirköprü Dam Lake, whereas in the present study these values were 11.92 cm and 3020 eggs. In each species, the individual fecundity is subject to very great variation, due primarily to the variation in size of the fish. The differences between age and length compositions for the different populations of the same species and ecological and geographic differences among the habitats cause significant changes in the fecundity values (Nikolsky, 1963; King, 2007). Average egg number was 3020 for II. age group, and 13424 for V. age group in Tödürge Lake (Table V). As can be seen, there was an increase in the numbers of eggs with the increasing age of the fish. A similar result have also been reported for *A. chalcoides* population in Demirköprü Dam Lake (Balık & Sarı, 1994). In the majority of fishes, the number of egg at first gradually increases with age, and then, as the individual approaches senility it usually begins to decrease. In addition, the fecundity in a single population may undergo considerable fluctuations in relation to the supply of nourishment. Small populations therefore, must have much higher fecundity (Nikolsky, 1963).

In conclusion, current condition of *A. chalcoides* population in Tödürge Lake must be kept constant. It is thus an imperative that fishing must be prohibited during the spawning period, which lasts from May and July, to ensure economic evaluation and the sustainability of the population. Finally, it is of great importance to give each fish the chance of reproduction at least once in its life span and therefore, the smallest prey size allowed for commercial fishing must be based on the length and weight averages of the age group III.

REFERENCES

Akyurt, I. and M. Sarı, 1991. Investigations on some biological and ecological properties of shemaya (*Chalcalburnus chalcoides* Güldenstaedt, 1772) living in different habitats. *J. Fish. Aquatic Sci.,* 8: 87–101

Balık, S. and H.M. Sarı, 1994. *Investigations on Growth of Chalcalburnus chalcoides Güldenstaedt, 1772 Population in Demirköprü Dam Lake (Salihli-Turkey).* XII. National Biology Congress, Edirne

Balık, S., M.R. Ustaoğlu, H.M. Sarı and M. Özbek, 1996. Investigations on biological properties of shemaya (*Chalcalburnus chalcoides* Güldenstaedt, 1772) in Manyas Bird Lake (Bandırma-Turkey). *J. Fish. Aquatic Sci.,* 13: 171–182

Berg, L.S., 1949. *Freshwater Fishes of the U.S.S.R. and Adjacent Countries*, Vol. 2. Academy of Sciences of the U.S.S.R. (Translated from Russian, Israel Program for Scientific Translations, Jerusalem-1964)

Bogutskaya, N.G., 1997. Contribution to the knowledge of Leuciscinae fishes of Asia Minor. *Mitt. Hamb. Zool. Mus. Inst.,* 94: 161–186

Bogutskaya, N.G. and A.M. Naseka, 2004. *Catalogue of Agnathans and Fishes of Fresh and Brackish Waters of Russia with Comments on Nomenclature and Taxonomy.* Russian Academy of Sciences, Moscow

Freyhof, J. and M. Kottelat, 2007. *Alburnus vistonicus*, a new shemaya from eastern Grecee, with remarks on *Chalcalburnus chalcoides macedonicus* from Lake Volvi (Teleostei:Cyprinidae). *Ichthyol. Explor. Freshwaters,* 18: 205–212

Geldiay, R. and S. Balık, 1988. *Turkish Freshwater Fishes.* Ege University, Science Faculty, Series of Books, No: 97, İzmir

Herzig, A. and H. Winkler, 1986. The influence of temperature on the embryonic development of three cyprinid fishes, *Abramis brama*, *Chalcalburnus chalcoides mento* and *Vimba vimba*. *J. Fish Biol.,* 28: 171–181

King, M., 2007. *Fisheries Biology, Assessment and Management,* 2nd edition. Wiley-Blackwell

Lagler, K.F., 1956. *Freshwater Fishery Biology.* W.M.C. Brown Company, Iowa

Nikolsky, G.V., 1963. *The Ecology of Fishes.* Academic Press, London and New York

Slastenenko, E., 1955. *Fishes of Black Sea Basin.* State Corporation of Meat and Fish Products Publication, İstanbul

Unver, B. and F. Erk'akan, 2005. A natural hybrid of *Squalius cephalus* (L.) and *Alburnus chalcoides* (Güldenstadt) (Osteichthyes-Cyprinidae) from Lake Tödürge (Sivas, Turkey). *J. Fish Biol.,* 66: 899–910

Unver, B., 1998. An investigation on the reproduction properties of chub {*Leuciscus cephalus* L., 1758) in Lake Tödürge (Zara-Sivas). *Turkish J. Zool.,* 22: 141–147

Ünver, B. and J. Tanyolaç, 1999. Growth properties of chub (*Leuciscus cephalus* L., 1758) in Lake Tödürge (Zara-Sivas). *Turkish J. Zool.,* 23: 257–270

West, G., 1990. Methods of assessing ovarian development in fishes, a review. *Australian J. Mar. Freshwater Res.,* 41: 199–222

Yarar, M. and G. Magnin, 1997. *Important Bird Areas of Turkey.* WWF, İstanbul, Turkey

(Received 19 March 2011; Accepted 22 August 2011)